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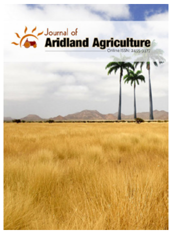

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Evaluation of the quality status of African nightshade seed produced by farmers in Kenya

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ABSTRACT

Seed is such an important input in crop production that it should be of high quality, pathogen free and have desired germination rate. This study was undertaken to evaluate the quality status of African nightshade (*Solanum scabrum* and *S. villosum Miller*) seed produced by farmers in Kenya. A household survey was conducted in 240 farms using a structured questionnaire to capture seed production systems and post-harvest practices that influence seed production. A total of 164 samples of farm saved, market and certified seeds were obtained during this survey. Seed samples were tested for quality and the pearson's correlation between seed quality and germination parameters was done. The analysis showed that 50% of farmers use farm saved seed while 28% purchased seed from the local markets which have low purity and germination rates. Seed samples from different sources differed ($p<0.05$) significantly with regard to seed purity, moisture content, seedling vigor index and germination percentage. Farm saved and seed obtained from the local market had low seed purity of 68.6 and 74%, respectively, compared to certified seed at 94.4%. In addition, only certified seeds met the recommended moisture and germination percentage as per the International Seed Testing Association (ISTA) standards. There was significant ($p\leq 0.05$ and $p\leq0.01$) positive correlation between seed quality and germination parameters, for example seed purity had significant positive correlation ($r=0.76^{**}$) with germination percentage. This study affirms that farmers are using low quality seeds.

KEYWORDS: African nightshade, Farm saved seed, germination percentage, seed purity

INTRODUCTION

African nightshade has the potential to address food security and nutrition, particularly for poor urban and rural households [1]. It has a history of cultivation and domestication to African conditions and whose leaves and fruits are used as vegetables [2]. ANS is an important source of micronutrients, fibre, vitamins, minerals and proteins [3]. Majority of farmers either use seed saved from their crops, seed from neighbors or from local markets often with problems of both purity and germination [4]. The absence of good quality seed leads to significance production losses affecting household incomes and food security [1]. The informal seed acquisition in Kenya accounts for 90% of the African nightshade seed used by farmers [3]. Farmers do not use certified seed due to limited supply, high prices and lack of knowledge on its importance [1].

Planting of high quality seeds is the first step towards optimizing crop production. Selection of a good seed should be based on the various quality attributes; genetic purity, physical purity, seed health, seed viability, seed vigour and moisture content [5]. Seeds obtained either saved from their own previous crop or from the local markets have problems of purity with mean germination rates rarely above 50% [6]. International rules on seed testing (ISTA) recommends the methods to be used by all seed testing laboratories when testing seed for trade and in the enforcement of national laws for the control of seed quality [5]. Continued cultivation of recycled farm saved seed leads to overall decline in seed quality due poor handling and accumulation of seed borne diseases. To prevent yield losses there should be adequate supply of certified seed. The objective of this study was to evaluate the quality status of the African nightshade (*Solanum scabrum; S. villosum miller*) seed produced by farmers in Kenya.

MATERIALS AND METHODS

Description of Sampling Regions

Seed samples were collected from four sites where African nightshade is grown in large quantities as a cash and food crop. These sites were Suneka and Ogembo in Kisii; Lurambi and Amalemba in Kakamega, Kenya. Global positioning system (GPS) was used to locate the sites. Suneka is located at latitude of 0° 40'

43.5" S and longitude of 34° 42' 27.7"E in upper midland zones AEZ UM 2. The soil types in this site are chromoluvic phaeozems, partly pisofernic phase and mollic nitisols. The average annual rainfall is 800-1000mm, temperatures ranging from 18-21°C and altitude range between 1500-2000 metres above sea level (a.s.l). Ogembo is located at latitude of 0° 50' 18.8" S and longitude of 34° 43'47.6"E in lower highlands zones AEZ LH 2. The soil type is chromic vertisols and eutric planosols and chromic-luvic phaeozems. The average annual rainfall is 1300-1600 mm, temperatures range from 15-18°C and altitude range of 2000-2500 m a.s.l [7-8]. Amalemba is located at latitude 0° 16' 14.4" N and longitude 34° 45' 14.6" E in upper midlands zone AEZ UM 4. The soils are well drained, extremely deep, dark-reddish brown, friable clay, with humic topsoil (basalts and nepheline phonolites). The altitude range is 1500-1900 m a.s.l, rainfall between 1000-1600 mm and temperature range of 18-21 °C. Lurambi is located at latitude 0° 17' 42.5" N and longitude 34° 4' 47.9" E in the lower midlands AEZ LM 2. The soils are well drained, moderately deep, dark red, friable clay, over petroplinthite, with inclusions of small bottom lands (rhodic ferralsols, petroferric phase).The altitude range is 1300-1500m a.s.l, rainfall range 1500-1800mm and temperatures range 20-22 °C [7-8].

Farm Household Survey and Seed Collection

To achieve this objective a farm household survey and seed collection was done in August, 2017 after March/April long rains. During the household survey, farm saved seeds were randomly sampled from households who had some seed to sell or spare to be used for quality and germination analysis. The respondents were selected using purposive sampling targeting farmers who grow African nightshades. The survey was carried out to examine household demographic information, seed production systems and post-harvest seed handling.

Sampling Method and Sample Size

Data collection methods for this research involved the use of both qualitative and quantitative methods. Qualitative method involved use of key informant interviews and quantitative method involved administration of structured questionnaire. The tools for data collection during the survey included structured questionnaire, form collecting primary data and key informant interviews. Interviews and seed collection was carried out by properly trained and carefully selected enumerators recruited from the local community. The questionnaire was pretested using a sample of 20 farms and revised accordingly. The targeted respondent was the household head, but in their absence, the spouse of the household head or a close relative or next of kin was interviewed in their place.

The households to be interviewed during the survey was calculated using the formula adopted from Fischer et al., (1998) that is $\eta = z^2 pq\, d^2$. η= sample size, z= standard deviation at the required confidence level (1.96), p= the proportion of population tested at 0.05, q= the proportion of the population not tested at 0.05 and d=statistical significance at 0.05. Using the formula, the required sample size was 384 but because of the limited number of household growing African nightshade only 240 farmers were interviewed. The target population was 4976 (Data on farmers who grow indigenous vegetables was provided by Extension staff at the sub county level in each strata). Proportional allocation was considered most efficient to make the probability of selecting a farmer in any strata to be equal and minimize variations within strata hence increasing reliability. In addition to the above sample size, ten key informants were selectively interviewed with respondents from research/extension, seed companies and seed stockists. In addition to 120 farm saved seed samples collected during survey, 40 local markets and 4 certified seeds samples were obtained from the agro-shops located in the Agro ecological zones to be used as standard check. A standard weight of 50g per sample was maintained and samples were put in brown paper (khaki) bags and kept at 5 °C cool storage cabinet at the University of Nairobi awaiting seed quality and germination analysis.

Determination of Seed Quality and Seed Weight

From each seed sample, 10g replicated thrice was used in determination of seed purity. Seed samples were separated into pure seeds, other crop seeds, inert matter, and discoloured, shriveled and insect damaged seeds. Each component was weighed separately and the percentage fraction calculated as:

$$\frac{\text{Weight of each component}}{\text{Total test sample weight } (10\text{g})} \text{x } 100$$

Determination of Seed Moisture Content and Germination Potency

Seed moisture content was determined by removing water from seed by heating in an oven, and the lost weight determined as follows. Two empty containers were weighed; seeds placed into containers and weighed subtracting the weight of the container; seeds were crushed into small pieces and then dried in the oven at ± 103°C for ± 17 hours. The samples were allowed to cool in an incubator for 15 minutes, then the dry sample was weighed and moisture content calculated [9]. The percentage moisture content was calculated by subtracting the weight of seed materials before drying (initial weight) and weight of seed material after drying (final weight) divided by initial weight of seed material and multiplied by 100.Three replications of 50 seeds from each source were distributed over blotting paper sheets, moisturized with an amount of water equivalent to 2.5 times weight of paper, inside plastic boxes (11.0x11.0x3.5 cm) and exposed to 20-30 °C with 8 hours of light and 16 hours of darkness. The evaluations on first and final germination percentages, seedling emergence, and seedling vigor index and seedling length were performed at 7 and 14 days in germination chamber after sowing in compliance with the rules for seed testing [6]. Seedling vigor index was calculated as seedling length (cm) x germination percentage [10].

Data Analysis

Information from the survey questionnaire was coded on a numerical scale and entered into a spread sheet. The responses were summarized and similar responses combined, coded and analyzed using IBM® SPSS version 20. Data was presented using summary tables, charts and graphs. Missing data was excluded on a case by case basis. The mean values were used for statistical analysis. Seed quality and germination tests, pearson's correlation coefficients comparing seed quality and germination parameters were analyzed using statistical software version 9.2 (SAS; 2002). Means separation was done using least significant difference (LSD) Tukey's studentized range (HSD) test ($p \leq 0.05$), where applicable.

RESULTS

Demographic Characteristics of African Nightshade Seed Growing Households

The survey established that 73.3%of the households were male-headed 73.3 % but the respondents were mostly female 71.6%. Majority of the households sampled had between five to ten members representing 50% and majority existed within the marriage step up 65%. The distribution of the household head's level of education showed that most 92.9% were literate; with 58.8% having primary school education; 31.3% with secondary education; 2.1% having tertiary education while 7.1% were illiterate. Majority of the respondents who were growing African nightshade were full-time farmers 77.5% followed by informal employees 6.3%, formal employees 5.4%, casual workers 3.3% and others 2.1%. Majority of the respondents were cultivating the African nightshade on ancestral land 63.8% followed by those who bought land at 23.8% then rented 8.3% and others (4.2%) (Table 1).

The results indicated that the distribution of the farm sizes was skewed towards small land sizes with the majority of farmers having less than 2 acres contributing to 51% of the total farm sizes. In addition, few farmers (0.1%) own large parcels of land with majority being small scale farmers (Figure 1).

Preference of African Nightshade (*Solanum* spp.) Species in Different Ecological Zones

Solanum villosum is the most preferred species of African nightshade in agroecological zones UM2 (83%) and LH2 (88%), in Kisii, while *Solanum scabrum* is the prefered species in Agroecological zones LM2 (78%) and UM4 (73%), in Kakamega. In addition, *Solanum villosum* is least prefered and scantly cultivated in Kakamega Agroecological zones LM2 (22%) and UM4 (25%) while *Solanum scabrum* is least prefered and grown in Kisii Agroecology with UM2 18% and LH2 13% (Figure 2).

African Nightshade Seed Sources

Results from this study showed farm saved seed being the most commonly used by the farmers 50% followed by the market seed 28%. More farmers exchange seeds 9% than buy them from agro-shops (5%). Research institutions provide more African nightshade seed (3%) compared to the line Ministry of Agriculture (2%) (Figure 3).

Post-harvest Seed Handling By Farmers

Most farmers sampled (61%) reported to have experienced pests and diseases on African nightshade seeds in storage. Few farmers (35.4%) used seed protection measures to prevent seed damage. The study showed that majority of farmers (99.7%) did not grow and manage crops grown for seed production differently from that for vegetable

Table 1: Characteristics of farm households head and respondents in a survey on African nightshade.

Parameter	Frequency	% of total respondents
Gender of the household (HH) head		
Male	176	73.3
Female	64	26.7
Gender of the respondents		
Male	68	28.3
Female	172	71.6
Age (HH) head (years)		
21-30	7	2.9
31-40	35	14.6
41-50	55	22.9
51-60	69	28.8
Above 61	74	30.8
Size of the household		
1-5	72	30.0
6-10	120	50.0
11-15	39	16.3
Above 15	9	3.7
Marital status		
Married	156	65.0
Single	22	9.2
Separated	46	19.2
Widowed	16	6.6
Education level (HH) head		
Primary school	141	58.8
Secondary school	75	31.3
None (illiterate)	17	7.1
Tertiary (Colleges/University)	7	2.8
Occupation of (HH) head		
Farmers	186	77.5
Formal employees	13	5.4
Business persons	7	2.9
Business persons and farmers	6	2.5
Informal workers e.g., masons/ artisans	15	6.3
Casual workers	8	3.3
Others	5	2.1
Type of land ownership		
Ancestral	153	63.8
Bought	57	23.8
Rented	20	8.3
Others	10	4.2

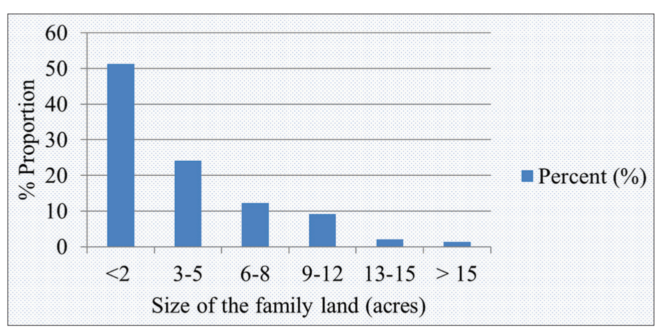

Figure 1. Size of family land

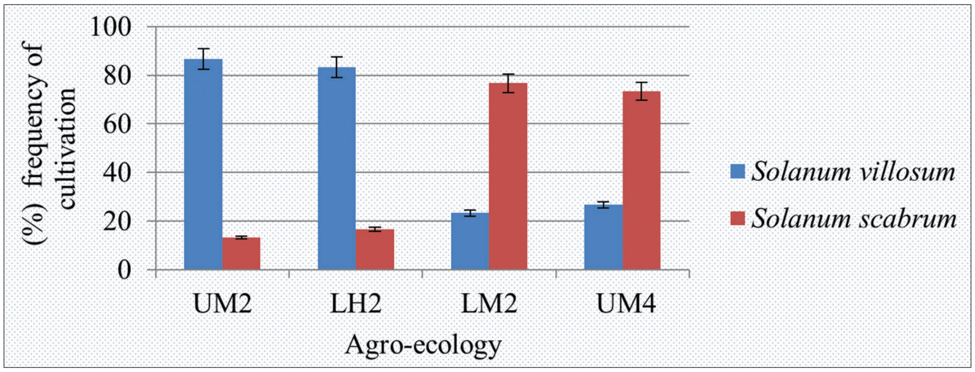

Figure 2. *Solanum* species (%) cultivation preference in the Agroecological zones.
UM2: Upper midland zone two, LH2: lower highland zone two, UM4: upper midland zone four and LM2: lower midland zone two

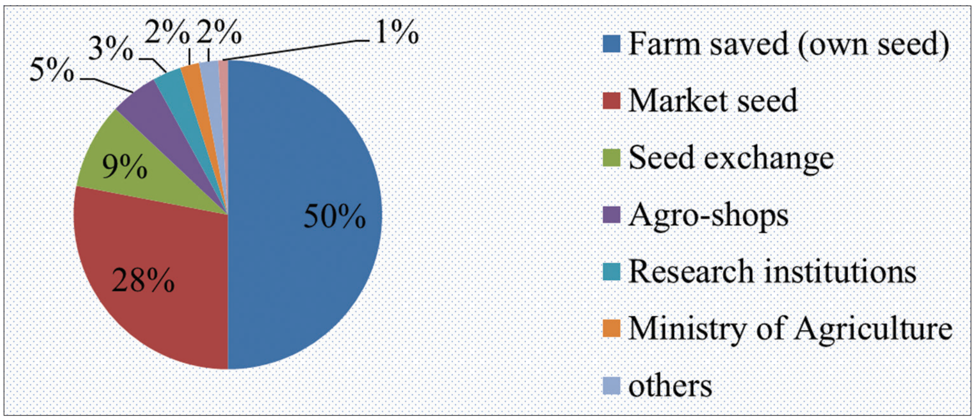

Figure 3. Sources of African nightshade seeds in the Agro- ecological zones

production. Farmers had varied responses on the seed harvesting state with majority harvesting the seed when ripe (83.8%) followed by those who harvested when unripe (14.2%) and a few harvest when dry (2%). After the seeds are harvested most farmers process them by wet processing (53.3%) followed by dry processing (32.5%) and a significant number do not process the seeds (14.2%). Seed was mostly stored in synthetic gunny bags (41.7%), with other storage material being gourds (21.3%), plastic cans (20.8%), polythene bags (7.5%), earthen pots (6.3%) and paper bags (2.5%) (Table 2).

Seed Purity

The seed purity differed ($p \leq 0.05$) significantly when certified seed, was compared to seed from the local market and farm saved seed. The seed purity in certified seed was 94%, compared to seed from the local market and farm saved which was 74 and 68%, respectively. Certified seed of *Solanum scabrum* and *Solanum villosum* had the lowest proportion of other crop seeds, inert matter, discolored seeds, shriveled seeds and insect damaged seeds. Farm saved and seed from the local market had higher proportions of other crop seeds, inert matter, discolored seeds, shriveled seeds and insect damaged seeds compared to certified seed (Table 3).

Seed Germination and Seedling Parameters

Solanum scabrum and *S. villosum* seeds from different sources differed ($p \leq 0.05$) significantly in all parameters tested. Farm saved and market seed had higher moisture content of above 10% while certified seed had moisture content of less than 10%. Certified seed had the highest germination percentage of over 85% while farm saved and market saved had low germination percentages of 72 and 68%, respectively (Plate 1 and 2). In addition, certified seeds had higher first count germination, seedling emergence, seedling vigor index and seedling length and significantly differed with farm saved and market seed which were lower (Table 4 and 5).

The proportion of germinated seedlings was higher in certified seed (96%) and differed $P \leq 0.05$ significantly with market (78%) and farm saved (72%) and a similar trend was followed for normal seedlings (Figure 2). Farm saved seeds had the highest abnormal (18%), mouldy (8%) and infected seedlings (12%) followed by market abnormal (12%), mouldy (6%) and infected seedlings (8%) and the lowest percent proportions were recorded in certified seeds: abnormal (8%), mouldy (4%) and infected seedlings (2%). (Figure 4-6).

Seed Purity and Germination Parameters Correlation

Seed purity showed a high significant and positive correlation with germination percentage ($r=0.76^{**}$), seed vigor index ($r=0.76^{**}$) and seed weight ($r=0.48^{*}$) and non-significant correlation with seed moisture content and seedling length on farm saved seed. Seed moisture content only correlated

Table 2: Post-harvest seed handling by the small scale farmers in the Agro-ecological zones

Parameter	Frequency	Percentage
Existence of pests and disease problem in stored grains		
Yes	145	61
No	95	39
Total	240	100
Use of seed protection measures to control pests and diseases		
Yes	109	45.4
No	131	64.6
Total	240	100
Seed crop grown and managed separately from the vegetable crop?		
Yes	3	0.3
No	237	99.7
Total	240	100
Seed harvesting state		
Ripe	201	83.8
Unripe	34	14.2
Dry	5	2.0
Total	240	100
Seed processing		
Wet processing & drying	128	53.3
Dry processing	78	32.5
Unprocessed	34	14.2
Total	240	100
Drying method		
Sun drying	236	98.3
Shade drying	4	1.7
Total	240	100
Seed storage		
Gunny bags	100	41.7
Gourds	51	21.3
Plastic cans	50	20.8
Khaki bags	6	2.5
Earthen pots	15	6.3
Polythene bags	18	7.5
Total	240	100

Table 3: Mean percentage seed purity parameters from the seed sources in the four Agro ecological zones

Seed sources	Pure seed	Other crop seeds	Inert matter	Discolored seeds	Shriveled seed	Insect damaged
[1]SS (market)	75.9[a]	5.2[b]	6.0[b]	5.6[b]	3.4[b]	4.0[b]
SS (farm saved)	69.6[a]	6.4[b]	5.9[b]	6[b]	5[b]	6.1[b]
SS (Kenya seed)	94.8[b]	2.0[a]	2.1[a]	1.0[a]	0.0[a]	0.0[a]
[2]SV (market)	74.0[a]	4.8[ab]	4.4[b]	5.8[b]	5.2[b]	5.8[b]
SV (Farm saved)	68.6[a]	5.3[b]	5.6[b]	6.1[b]	7.3[c]	6.4[b]
SV (Certified seed)	94.4[b]	2.1[a]	1.5[a]	2.0[a]	0.0[a]	0.0[a]
[3]Lsd ($p \leq 0.05$)	14.7	2.7	1.9	3.3	2.0	3.3
[4]Cv%	29.2	27.3	34.2	32.2	31.8	32.2

[1]*Solanum scabrum*, [2]*Solanum villosum*, [3]least significant differences and [4]coefficient of variation. Values are the means, each having three replicates. Means followed by the same letter(s) within columns are not significantly different ($p \leq 0.05$) while those followed by the different letter(s) within columns are significantly different; means are separated by LSD ($p \leq 0.05$)

significantly with seed weight (r=0.56*) and had insignificant correlation with other parameters. Seed germination (%) had a high significant and positive correlation with seedling emergence (r=0.63**), seedling length (r=0.68**), seedling vigor index (0.87**) and not significant with seed weight (r=0.32). Seedling emergence had a positive correlation with seedling length (r=0.54*) and seedling vigor index (0.64**) and non-significant correlation with seed weight (Figure 5).

DISCUSSION

The study has revealed that most of the respondents were women. This shows that most of the men are usually engaged in other activities outside the farms but they were the household heads. This implies that women are most likely the drivers of crop production and also the recipients of agricultural extension messages and the decision makers with regard to production of African nightshade. Similar findings were reported by [11] that women constitute over 60% of the agricultural work force. Most household heads were aged above 50 years hence the need for a strategy to engage youth in production of African nightshade. Most farmers were literate and if adequately trained are capable of adopting and carry out agricultural practices. Most farmers relied on agriculture as an occupation (77.5%) and the findings agree with the report by [12] that two thirds of farmers are dependent on farming for their livelihoods. Majority of farmers cultivate African nightshade in small land holdings and this limits production due to competition for land resource allocation.

Solanum scabrum and *Solanum villosum* are widely cultivated in Nyanza and Western Kenya as farmers prefer them for their edible leaves and fruits. According to [13], the two species are among the most intensively cultivated leafy vegetables. Farmers in these agro ecological zones prefer *Solanum scabrum* due to its ability to grow faster, adaptation to climatic conditions in warmer humid agro ecologies and its large sized leaves that are good for consumption and lack of bitter taste. Similar findings were reported by [14] in western agro ecological zones. Its seeds are also readily available in farms and market outlets. However, it was less cultivated in Kisii. Similar findings were reported by [15] and [16] that *Solanum scabrum* was absent in Kisii-Nyamira but was intensively and widely cultivated in Kakamega and Busia counties. Solanum villosum was the most preferred in Kisii UM2 and LH2 agro ecological zones because it adapts well to the climatic conditions in the area, grows fast and ease of seed availability [15]. The availability of seeds of the same crop species in farms and market outlets could also be a major contributor to differing preference.

Majority of farmers reported to experience storage pests and diseases but only 35.4% of survey respondents used crop protection chemicals. Farmers usually cultivate farm saved seed (50%) and less of clean certified seed (5%) and farmers do not select crops for seed production. In addition, almost all the farmers' sun dried their seeds as opposed to drying under shade leading to further loss in seed quality. [17] reported that sun drying of seed reduces seed quality by affecting seedling radicle length, seedling dry weight and speed of germination. The high temperature and U.V radiation accelerates respiration rate, causes seed breakage, bleaching, scorching and discoloration, damage to seed coat and loss of nutritional quality [12].

Table 4: Germination parameters of seeds from different sources in the four Agro ecological zones

	Sites	Seed Source	MC (%)	FG (%)	FCG (%)	SE (%)	SVI	SL (cm)
1	UM2	Farm saved	12.4^{b}	66^{b}	44^{a}	74^{a}	211^{a}	3.2^{a}
		Market seed	12.1^{b}	68^{b}	53^{b}	75^{a}	252^{a}	3.7^{a}
2	LH2	Farm saved	13.9^{bc}	69^{b}	51^{b}	76^{a}	242^{a}	3.5^{a}
		Market seed	10.0^{ab}	56^{a}	53^{b}	73^{a}	235^{a}	4.2^{b}
3	UM4	Farm saved	15.4^{c} b. 4^{b}	73^{b}	59^{bc}	81^{b}	234^{a}	3.2^{a}
		Market seed	13.4^{bb}	76^{bc}	61^{c}	83^{b}	327^{c}	4.3^{b}
4	LM2	Farm saved	14.0^{b}	82^{c}	65^{c}	86^{b}	238^{a}	2.9^{a}
		Market seed	11^{ab}	75^{b}	62^{c}	84^{b}	285^{b}	3.8^{a}
5	Certified seed	-	7.5^{a}	85^{c}	74^{d}	92^{c}	432^{d}	4.8^{b}
	[1]Lsd P<0.05		2.6	8.6	6.1	5.4	24.3	1.2
	[2]CV (%)		14.4	16.7	22.8	32.4	12.4	6.8

[1]Least significant difference. [2]Coefficient of variation. Means followed by the same letter(s) within columns are not significantly different (p≤0.05) while those followed by the different letter(s) within columns are significantly different; means are separated by LSD (p≤0.05).UM2-Upper midland zone two; LH2-lower highland zone two; UM4-upper midland zone four; LM2-lower midland zone two. Moisture content (MC), final germination (FG), first count germination (FCG), seedling emergence (SE), seedling vigor index (VI) and seedling length (SL).

Table 5: Germination parameters of seeds from different sources in the four Agro ecological zones

	AEZ	Seed Source	MC (%)	FG (%)	FCG (%)	SE (%)	SVI	SL (cm)
1	UM2	Farm saved	12.4^{ab}	69^{ab}	54^{ab}	68^{ab}	193^{a}	2.8^{a}
		Market seed	11.1^{a}	72^{ab}	48^{a}	72^{ab}	281^{cd}	3.9^{ab}
2	LH2	Farm saved	12.3^{ab}	71^{ab}	53^{a}	65^{a}	241^{b}	3.4^{ab}
		Market seed	11.2^{a}	62^{a}	56^{ab}	78^{bc}	267^{c}	4.3^{b}
3	UM4	Farm saved	15.6^{b}	76^{b}	55^{ab}	74^{b}	281^{cd}	3.7^{ab}
		Market seed	14.4^{b}	74^{b}	64^{b}	78^{bc}	237^{b}	3.2^{ab}
4	LM2	Farm saved	13.0^{ab}	79^{bc}	68^{bc}	76^{bc}	260^{bc}	3.3^{ab}
		Market seed	10 ^{a}	78^{bc}	67^{b}	83^{c}	297^{d}	3.8^{ab}
5	Certified seed	-	8.3^{a}	88^{c}	76^{bc}	95^{d}	422^{f}	5.7^{c}
	[1]Lsd *P*<0.05		3.1	10.4	9.3	8.2	29.3	1.3
	[2]CV (%)		21.2	14.2	21.4	22.8	23.1	13.6

1Least significant difference. 2Coefficient of variation. Means followed by the same letter(s) within columns are not significantly different (p≤0.05) while those followed by the different letter(s) within columns are significantly different; means are separated by LSD (p≤0.05).UM2-Upper midland zone two; LH2-lower highland zone two; UM4-upper midland zone four; LM2-lower midland zone two. Moisture content (MC), final germination (FG), first count germination (FCG), seedling emergence (SE), seedling vigor index (VI) and seedling length (SL).

Table 6: Pearson's correlation (r) on seed quality parameters in African nightshade.

Experiment 1							
Correlation Parameters	SP (%)	MC (%)	G (%)	SE (%)	SL (cm)	SVI	SW (g)
SP (%)							
MC (%)	-0.32^{ns}						
G (%)	0.76**	-0.04^{ns}					
SE (%)	0.28^{ns}	-0.24^{ns}	0.63**				
SL (cm)	0.22^{ns}	0.22^{ns}	0.68**	0.54*			
SVI	0.70**	0.27^{ns}	0.87**	0.64**	0.95**		
SDW (g)	0.48*	0.56*	0.32^{ns}	-0.02^{ns}	0.02^{ns}	0.36^{ns}	
Experiment 2							
Correlation parameters	SP (%)	MC (%)	G (%)	SE (%)	SL (cm)	SVI	SW (g)
SP (%)							
MC (%)	-0.29^{ns}						
G (%)	0.78**	-0.01^{ns}					
SE (%)	0.34^{ns}	-0.30^{ns}	0.65**				
SL (cm)	0.18^{ns}	0.23^{ns}	0.69**	0.51*			
SVI	0.67**	0.33^{ns}	0.89**	0.71**	0.92**		
SDW (g)	0.49*	0.67**	0.36^{ns}	-0.23^{ns}	0.23^{ns}	0.33^{ns}	

SP: Seed purity, MC: Moisture content, G: Germination %, SE: Seedling emergence, SL: Seedling length, SVI: Seedling vigor index and SDW: 1000 Seed weight. *,** Significant correlation at P≤0.05 and P≤0.01 respectively, ns: non-significant at P≥0.05.

This study has revealed that non-certified African nightshade seed saved by farmers and those sold in the market outlets are of extremely low quality. The farm saved and market seeds failed to meet the recommended minimum standard for pure seed of 95% [5]. Market saved seed had less proportion of impurities compared to farm saved seeds; this could be attributed to the fact that farmers take more time to prepare seeds for market to attract customers. Certified seed had lower proportion of impurities compared to farm and market saved seeds. This could be attributed to good crop production and post-harvest practices by the seed company that leads to clean seeds. The findings agree with those of [12] which reported low fraction of weed and foreign materials in formal seed compared to farm saved seed. In addition, [18] reported that low purity levels in seed could be due to poor crop husbandry and post-harvest management practices by farmers such as threshing, stage of harvesting, drying and storage. The high proportions of discolored and shriveled seeds, abnormal, mouldy and infected seedlings in the farm saved seeds compared to certified seeds could be attributed to high prevalence of seed borne diseases in recycled seeds leading to build up of inocula. Similar findings by [19] reported that certified seeds are genetically pure and free from diseases, physical damage and immature seeds. Certified seeds met the recommended minimum

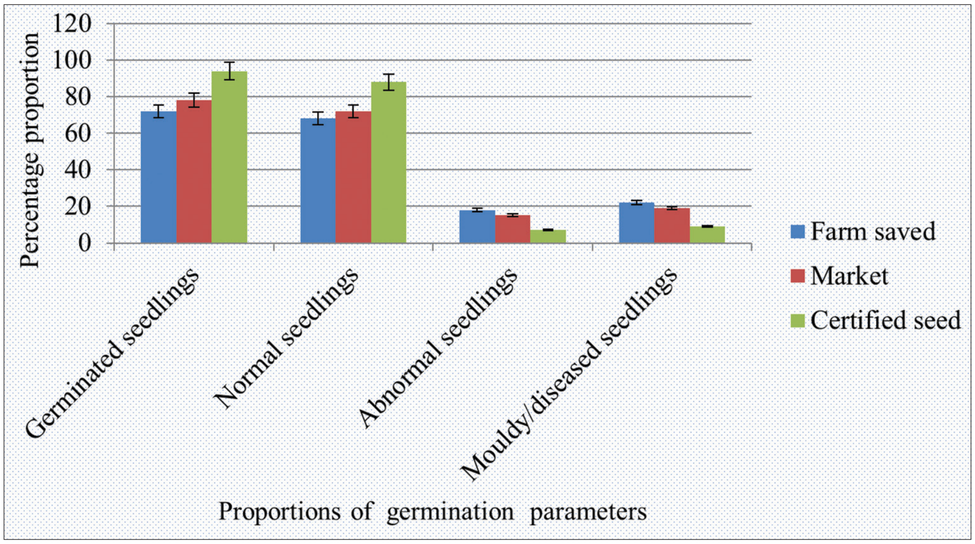

Figure 4. Mean proportions (%) of germinated, normal, abnormal, mouldy/diseased seedlings in seed samples

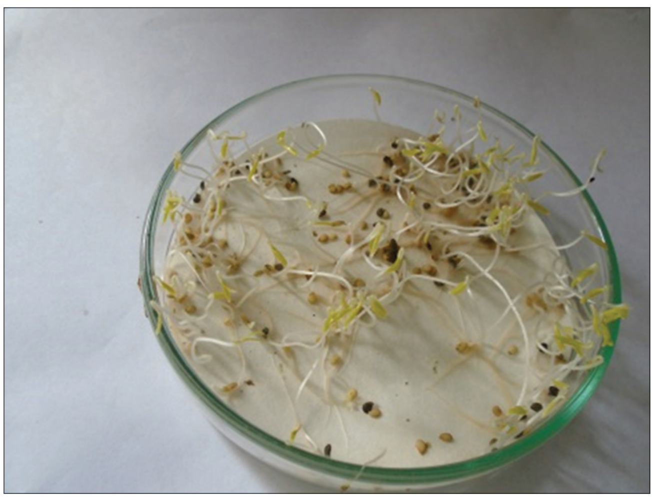

Plate 1. High germination (88%) in certified seed

Plate 2. Low germination (67%) in farm saved seed

germination percentage of 85% and moisture content of 10% as per international rules of seed testing. Poor storage of farm saved seed increases seed moisture content. This is known to reduce the longevity of the seed since any increase by 1% of moisture content can reduce seed storage life by approximately 50% [5]. The seeds should be dried to safe moisture levels, it is important to store them in leak-proof containers. Poorly stored farm saved seeds are exposed to storage pests and increases in moisture content, leading to reduction in seed longevity. Lower rates of germination, seedling vigor index and higher rates of moisture content in farm saved and market seeds could be attributed to poor pre and post-harvest handling and storage practices by farmers. Similar findings were obtained by [20] and [21] who reported that threshing and other post-harvest processes by farmers lowers the germination capacity and seedling vigor. Low germination and seed vigor of farm saved seeds could also be due to long storage periods in poor conditions.

Warm and humid climate in Kisii and Kakamega counties and poor post-harvest handling practices by the respective farmers could have led to low seed quality due to high moisture content which predisposes the seed to infection. Farmers' harvest the crop under wet weather conditions and seeds are poorly dried leading to high moisture content [3]. The end result is low seed vigor, poor germination and seed rotting. Seed quality had positive correlation with germination parameters showing that a pure seed is a good predictor of good crop performance. Similar results by [22] indicated that a pure seed has high germination percentage which results in a good crop stand.

CONCLUSIONS

African nightshade is mainly produced by small scale farmers who lack access to certified seed but rely on farm saved seed. Seed exchange was common among farmers and a few of them purchased seed from the formal seed market, mainly from Kenya Seed Company. Farm saved as well as seed purchased from the local market is of low quality and has poor germination attributes.

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AUTHOR'S CONTRIBUTION

All authors contributed to the design and execution of this study and in the development of the research paper.

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